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A Study on Data Visualization Techniques of Spatio Temporal Data

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ABSTRACT

Data visualization is an important tool to analyze complex Spatio Temporal data. The spatio-temporal data can be visualized using 2D, 3D or any other type of maps. Cartography is the major technique used in mapping. The data can also be visualized by placing different layers of maps one on other, which is done by using GIS. Many data visualization techniques are in trend but the usage of the techniques must be decided by considering the application requirements.

KEYWORDS: *Spatial data, Spatio-temporal data, Data visualization, GIS, Cartography*

I. Introduction

Nowadays the analysis of spatio-temporal data is getting importance, since it will help many researchers who are working on the applications of spatio-temporal data. This analysis helps them in making decisions. There are many techniques available for spatial-data analysis, among them Data Visualization is the one which helps the users to analyze the data with interactive maps. The spatial data that are received are bucketed, segregated, sliced and spliced according to the business rules. These strata of diced and joined information are spruced up in either a two-dimensional or a three dimensional representation which would empower an examiner or even a layman to comprehend the obvious elucidation. This kind of visualization can be done easily in the web-based environment. Even visualization of data in 3D format is also simpler in web based environment. The progression in the representation innovation has altered commercial ventures, for example, meteorological information, pharmaceutical, geographical data, global aid, repatriation and so on. Even though all these things have been achieved, the field of data visualization is facing many challenges since in web based environment the systems are not grown to their full potential level. The data related to a system can be collected from multiple sources. These data from multiple sources are merged and used. Since the data are collected from multiple sources, they result in big data systems. Map-reduce technique is able to solve this kind of problem which helps in decision making by the researchers. The currently techniques are not that much efficient to display the temporal data. Presently using graphical maps are not able to solve the complex multidimensional data relationships effectively. They fail at the level of capturing temporal information or at the different levels of spatial resolution. Data from cities; of utilities, transportation system, and housing are rich data with significant geospatial and temporal characteristics that consist of large quantities of data from a variety of data sources. Information must be stored efficiently and integrated to a common framework. A mapping between the information elements and their spatial and temporal locations may be used to provide information in meaningful format. This information is nothing but service information. This can be complex, multidimensional, physical or abstract information that is intrinsically difficult to represent, manipulate and deduce actionable information from.

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II. Related work

Data abstraction for the purposes of reducing visual clutter and dataset size is not a novel idea. Shneiderman's taxonomy of information visualization tasks touches upon important data abstraction operations such as filter and zoom as well as the importance of an overview. Oliveira and Levkowitz survey the use of visualization for data mining and discuss some standard data mining techniques for abstracting large-scale datasets, including dimension reduction (e.g., Principal Component Analysis), subsetting (e.g., random sampling), segmentation (e.g., cluster analysis), and aggregation. Our work in the present article is based on the latter technique—hierarchical aggregation of data items, where the original data items are used to create new and aggregated items.

Andrienko and Andrienko give a coherent treatment of data aggregation and its statistical foundations in exploratory data analysis, including a wide range of examples and techniques. On a related note, Billard and Diday introduce symbolic data analysis for statistical analysis of very large datasets. Many of the techniques described in the present article draw inspiration from this large body of knowledge, but our focus here is on hierarchical aggregation that allow for more dynamic visual exploration as opposed to the static aggregations traditionally employed in statistics. These techniques can often be adapted for hierarchical aggregation, both in data and in visual space.

Most recently, Ellis and Dix present a taxonomy that captures virtually all aspects and strategies of data abstraction for visualization. They identify 11 different strategies for data abstraction and give examples of each, classifying existing work into an annotated taxonomy using a set of criteria derived from the literature. Their approach involves three rough groupings of strategies: appearance (affecting the visual representation of individual data items), spatial distortion (displacing visual data items), and temporal (animation).

However, the work of Ellis and Dix ignores the potentially useful distinction between performing abstraction in data space and in visual space that is highlighted by Cui et al. More specifically, some abstraction methods—including filtering, clustering, and sampling operate on the actual items in the dataset, whereas others—such as distortion and zooming affect the visual presentation of the items. However, many authors fail to acknowledge the benefit of providing a link between abstraction methods in data space and their representation in visual space.

Drawing visual representations of abstractions performed in data space allows for creating simplified versions of visualization while still retaining the general overview. By dynamically changing the abstraction parameters, the user can also retrieve details-on-demand. Some existing work is based on this kind of visual aggregates; many of these techniques are presented in the body of this article in the relevant sections. To give a representative sampling, much of the inspiration for this article comes from the opacity representation of cluster results in parallel coordinates and starplots by Fua et al., edge aggregation in adjacency matrices by Elmqvist et al., and hierarchical edge bundles for node-link diagrams by Holten (although the latter is not strictly a hierarchical aggregation technique).

Yang et al. present a framework for interactive hierarchical displays that bears much resemblance to our work. In particular, they present hierarchical implementations for parallel coordinates, starplots, scatterplot matrices, and dimensional stacking. However, unlike our model, their framework is designed solely for multivariate datasets and specifies a concrete visual representation and color coding for the aggregates. Therefore, our model is slightly moregeneral, although by virtue of being more general, we also provide less guidance in actually implementing new multiscale visualizations.

As for the technical challenges of large-scale datasets, Fekete and Plaisant show how to overcome them for datasets on the order of 106 items using scatterplots and treemaps. However, their approach is to preserve all visible items in the visualizations without any data abstraction, so while their findings as well as similar findings on the scalability of visualization are useful for tool architects, they are not directly relevant to the more conceptual nature of this work.

III. Data visualization using GIS

GIS is emerged due to a number of operational necessities arising from the usage of digital maps in civil and military applications. The motif force which is spurred the development of GIS as an information system was thematic cartography i.e. composition of maps according to a particular

theme, collaborative visualization of operation information and application-specific map generation. Cartography involves surveying objects or features on, above and under the earth's surface such as land survey, aerial survey and survey of coastal zones etc. The graphic symbols representing the surveyed features with specific fonts, colour and styles were collectively called cartographic symbology.

The traditional cartographic process were quite human-intensive, inflexible and error-prone. As the digital processing technologies get advanced, the digital cartographic process replaces the traditional cartographic process. When remote sensing and satellite photography developed, the manual survey data were replaced by satellite images which could reflect recent terrain changes and thus were more authentic.

Earth features are digitized from the satellite image and after due interpolation, are assigned an appropriate symbol, colour, font and style to give a visual representation to the feature. Further, these features are characterized according to the common major and minor characteristic they possess (theme-wise).

The input domain of GIS is in the form of data, which are alpha-numeric representation of magnitude of different physical quantities. Data by themselves sometimes cannot convey information unless processed. Processed data conveys the meaning associated with the data, which is called information. The different input data are Raster scanned data, satellite image, vector map, attribute data, elevation data, marine navigation charts, coordinate system information, projection parameter, almanac and metrological data etc. The input domain contains three different types of data such as spatial data, temporal data and attributes data. Spatial data are those, which are associated with the coordinates (x,y) in a 2D-plane or (x,y,z) in a 3D-space. Temporal data are spatial data that have a time component attached to it. Attribute data otherwise called non-spatial data are attributes of earth objects which subjectively and objectively describe their nature.

The spatial data are modeled as vector model, Raster model and Digital Elevation model. The different types of spatial data modeling are Geometric modeling, thematic modeling and spatial modeling. The geometric modeling is the representation of geometric features and organizing them with respect to each other gives a spatial ordering. In thematic modeling, a group of terrains features are clustered together according to a common property or theme they share is known as thematic categorization or thematic modeling of terrain features. Modeling spatial information must take into consideration the object, as it is; the presence of the object with respect to the other objects; and finally the occurrence of the object in a larger topographical area. The relative positioning of the object is modelled using network models such as terrain irregular network (TIN).

IV. VISUALIZING DYNAMIC DATA

Static maps of relational data lead to visually appealing representations, which show more than just the underlying vertices and edges. Specifically, by explicitly grouping vertices into different colore regions, viewers of the data can quickly identify clusters and relations between clusters. Moreover, this explicit grouping leads to easy identification of central and peripheral vertices within each cluster.

Extending traditional graph drawing algorithms from static to dynamic graphs is a difficult problem. In most proposed solutions, the typical challenges are those of preserving the mental map of a viewer and ensuring readability of each drawing. Changes are visualized by animation, which can be generated by concatenating static maps, thus providing continuity from one layout to the next. Whereas in dynamic graph drawing it is perfectly reasonable to have vertices move from one moment in time to the next, moving "countries" and "cities" within the countries on a map can be confusing and counter-intuitive. Also, if the layout from one time to the next is significantly different, it is likely that viewers will quickly get lost. A common way to deal with this problem is anchoring some vertices that appear in two or more subsequent drawings. Additionally, the way to encode metrics and changes into the map metaphor needs to be considered. Next we describe how we address some of these challenges.

V. VISUALIZATION BY HIERARCHICAL AGGREGATION

The technique is based on aggregation in data space and corresponding simplified visual representations of the aggregates in visual space. Essentially, the aggregation process turns any visualization into a multiscale structure that can

be rendered at any desired level-of-detail. This provides the user with a manageable overview that hides any clutter arising from details in the dataset while still giving a reasonable indication of the data size, extents, or distribution through the visual aggregates. The visual aggregates can convey different information about the underlying data items, such as their average, extents, or even their distribution. Furthermore, the interaction allows the user to drill down and retrieve details on-demand. In this way, hierarchically aggregated visualization techniques directly support the visual information seeking mantra: "overview first, zoom and filter, then details on demand."

VI. Conclusion

Many different techniques or analogies can be used for visualizing spatial-temporal data. Among them some of the techniques has been collected and explained in this paper. The techniques used for spatio-temporal data visualization are application specific. So the need of application has to be analyzed first and then the appropriate visualization technique has to be opted.

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